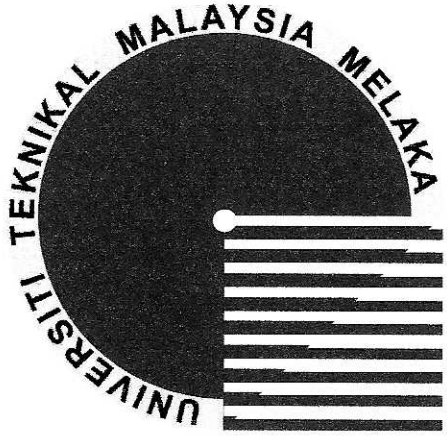

Faculty Of Manufacturing Engineering

MEASUREMENT OF SURFACE ROUGHNESS USING IMAGE PROCESSING TECHNIQUE

Luei Hong Keat

Master Of Manufacturing Engineering (Manufacturing Systems Engineering)

2010

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LUEI HONG KEAT

This report submitted in accordance with requirement of the Universiti Teknikal Malysia Melaka (UTeM) for the Master Degree of Manufacturing Engineering (Manufacturing Systems Engineering)

Faculty Of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2010

DECLARATION

I hereby, declared this report entitled "Measurement of Surface Roughness Using Image Processing Technique" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Master of Manufacturing Engineering (Manufacturing Systems Engineering). The members of supervisory committee are as follow:

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ABSTRACT

Measurement of surface roughness after completion of a machining process is a common procedure undertaken in order to analyse the quality of the end product so that the desired results are determined. Similar process will be repeated if the desired surface roughness quality is not achieved. Currently, contact method is applied and is commonly used where a stylus is drag across the surface of the work piece to obtain its profile. In this method, the work piece needs to be removed and placed on flat surface before measured. Therefore additional time required for setup, calibration, work piece removal and putting is back into machine holder. Time means cost in production. In order to reduce or eliminate non value added time, an alternative technique of measuring or determine surface roughness is required. Machining parameters like the cutting speed and feed will be set for rough cut and finishing cut for both material mild steel and aluminium. For mild steel rough cut speed will be 27000 rpm and feed will be 0.2 mm, while for finishing cut speed will be 30000 rpm and feed is 0.05mm. For aluminium rough cut speed is 62500 rpm with feed 0.5 and finishing cut speed 95000 rpm with feed 0.15mm. This research started with the application of vision camera in capturing work piece's surface images and using image processing technique through MATLAB computing software to calculate the Grey Level Co-occurrence Matrices (GLCM) features such as contrast, entropy, energy, homogeneity and correlations. Collected data will then be analysing using data mining to extract the data patterns for both material aluminium and mild steel surface. For aluminium, only 4 GLCM features are computed contributing to influence surface roughness that is homogeneity, energy, contrast and entropy. Whereas mild steel all 5 features were computed affect the roughness value. With the aid of latest software, information can be easily extracted and be analyse for research purposes and also be used in manufacturing, therefore this research will lead into development of automated intelligent machine tools.

DEDICATION

This work is dedicated to my beloved parents, without their caring support and the respect for education it would not have been possible.

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I would like to express my thanks to my supervisor Dr. Zamberi Bin Jamaludin for his invaluable guidance and suggestion throughout this project. Thanks are also extended to Mr Lokman Bin Abdullah as my co-supervisor and to Dr. Mohd Rizal Bin Salleh for his generous advice.

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TABLE OF CONTENT

		Page
ABSTRACT		**i**
DEDICATION		**ii**
ACKNOWLEDGEMENT		**iii**
TABLE OF CONTENT		**iv**
LIST OF TABLES		**vii**
LIST OF FIGURES		**ix**
LIST OF ABBREVIATIONS		**xii**
CHAPTER		
1	**INTRODUCTION**	
1.1	Introduction	1
1.2	Problem Statement	4
1.3	Objectives	5
1.4	Scopes	5
2	**LITERATURE REVIEW**	
2.1	Introduction to Image Processing	6
2.2	Metrology Inspection	8
2.2.1	Surface Finish Measurement	10
2.2.2	Machine Vision	12
2.2.3	GLCM	15
2.2.4	Data Mining	18
2.3	Recent Findings	19
2.3.1	Neural Network Systems	19
2.3.2	Speckle Correlation Technique	22
2.3.3	Machine Vision	25
2.4	Summary	29
3	**METHODOLOGY**	
3.1	Material	30

3.2	Equipment	30
3.2.1	Conventional Lathe Machine	31
3.2.2	MATLAB Computing Software	35
3.2.3	Microsoft Software	35
3.2.4	Surface Indicator Mitutoyo SJ-301	37
3.2.4.1	Operation Procedures	38
3.2.5	Vision Sensor	41
3.2.5.1	CCD Camera (JAI CM-200MCL)	41
3.3	Project Flow Chart	45
3.4	Program Flow Chart	46
3.5	Project Gantt Chart	47
3.6	Summary	48
4	**RESULTS AND DISCUSSIONS**	
4.1	Introduction	49
4.2	Results after Machining	50
4.3	Experiment Set-up	53
4.4	Graphical User Interface (GUI)	55
4.4.1	Programme Layout	56
4.5	Procedure in Using GUI	59
4.6	Data from GUI	66
4.7	Data Mining	87
4.7.1	Aluminium Result	88
4.7.2	Mild Steel Result	91
4.8	Result Summary	94
5	**CONCLUSION AND RECOMMENDATIONS**	
5.1	Conclusion	95
5.2	Recommendations	96
REFERENCES		**97**

APPENDICES

A	Haralick Texture Features
B	MATLAB Source Code
C	GLCM Features
D	Aluminium Rough Cut
E	Aluminium Finishing Cut
F	Mild Steel Rough Cut
G	Mild Steel Finishing Cut
H	Accuracy Test Table for Aluminium
I	Accuracy Test Table for Mild Steel

LIST OF TABLES

1.1	Comparison of the conventional surface roughness measuring method and the propose image processing technique.	2
2.1	Common Image file formats.	9
2.2	Average Roughness.	12
2.3	Features computed by standard MATLAB functions and form a vector representative of texture.	18
3.1	Material.	31
3.2	Lathe Machine Specification.	32
3.3	Standard Machine Parameters for Steel and Aluminium.	33
3.4	Actual Parameters.	35
3.5	Machining Operations.	35
3.6	SJ-301 Specifications.	38
3.7	Camera Specification.	42
3.8	Research Planning.	47
4.1	Diameter.	50
4.2a	Roughness for Rough Cutting of Aluminium	51
4.2b	Roughness for Finishing Cutting of Aluminium	51
4.2c	Roughness for Rough Cutting of Mild Steel	52
4.2d	Roughness for Finishing Cutting of Mild Steel	52
4.3	Abbreviation in GLCM Features	66
4.4a	Sample ARC1 Image	67
4.4b	ARC1 ROI GLCM Features	67
4.5a	Sample ARC2 Image	68
4.5b	ARC2 ROI GLCM Features	68
4.6a	Sample ARC3 Image	69
4.6b	ARC3 ROI GLCM Features	69
4.7a	Sample ARC4 Image	70

4.7b	ARC4 ROI GLCM Features	70
4.8a	Sample ARC5 Image	71
4.8b	ARC5 ROI GLCM Features	71
4.9a	Sample AFC1 Image	72
4.9b	AFC1 ROI GLCM Features	72
4.10a	Sample AFC2 Image	73
4.10b	AFC2 ROI GLCM Features	73
4.11a	Sample AFC3 Image	74
4.11b	AFC3 ROI GLCM Features	74
4.12a	Sample AFC4 Image	75
4.12b	AFC4 ROI GLCM Features	75
4.13a	Sample AFC5 Image	76
4.13b	AFC5 ROI GLCM Features	76
4.14a	Sample MSRC1 Image	77
4.14b	MSRC1 ROI GLCM Features	77
4.15a	Sample MSRC2 Image	78
4.15b	MSRC2 ROI GLCM Features	78
4.16a	Sample MSRC3 Image	79
4.16b	MSRC3 ROI GLCM Features	79
4.17a	Sample MSRC4 Image	80
4.17b	MSRC4 ROI GLCM Features	80
4.18a	Sample MSRC5 Image	81
4.18b	MSRC5 ROI GLCM Features	81
4.19a	Sample MSFC1 Image	82
4.19b	MSFC1 ROI GLCM Features	82
4.20a	Sample MSFC2 Image	83
4.20b	MSFC2 ROI GLCM Features	83
4.21a	Sample MSFC3 Image	84
4.21b	MSFC3 ROI GLCM Features	84
4.22a	Sample MSFC4 Image	85
4.22b	MSFC4 ROI GLCM Features	85
4.23a	Sample MSFC5 Image	86
4.23b	MSFC5 ROI GLCM Features	86

LIST OF FIGURES

2.1	Each pixel has a value from 0 (black) to 255 (white).	7
2.2	Surface roughness produced by common machining processes.	11
2.3	Basic function of a machine vision system.	12
2.4	Spatial relationships of pixels that are defined by this array of offsets, where d represents the distance from the pixel of interest.	15
2.5	Horizontal, vertical, left and right diagonals.	17
2.6	Schematic diagram of computer vision system	20
2.7	ANFIS architecture	20
2.8	Multi-layer feed forward ANN	22
2.9	Angular speckle correlation experiment set-up	23
2.10	Schematic diagram of experiment setup	24
2.11	a. part of speckle pattern image (8 bit) obtained by using CCD, b. binary speckle pattern image of the image in a., c, the area marked with a cross in b. is zoomed in to show the pixel values.	25
2.12	Set-up of inclined object of machine vision system	26
2.13	Actual system structure: S, white light source; L1, L3, L4, achromatic lenses; B, beam splitter; L2, high chromatic aberration lens; SP, spectrometer; MF, multimode optical fibre.	27
2.14	The system hardware setup	28
3.1	Lathe Machine	31
3.2	Lathe Machine Spindle speed option.	33
3.3	Lathe Machine bed speed.	33
3.4	Analyse Key Influencers	36
3.5	Data Modelling: Estimate	36
3.6	Accuracy and Validation: Accuracy Chart	36
3.7	Procedure using Data Mining for Excel	37
3.8	Roughness Tester Mitutoyo SJ-301.	37
3.9	SJ-301 Dimensions.	38
3.10	Detector has to be set parallel to the surface and work piece surface to be measured.	40
3.11	Detector Setup.	40

3.12	Camera dimension.	44
3.13	Project Flow.	45
3.14	Program Flow Chart.	46
4.1	Planning Flow Chart.	49
4.2	Camera setup.	53
4.3	Height of work piece during Image Capture.	54
4.4	Programme Design Flow Chart.	55
4.5	MATLAB GUIDE	56
4.6	Property Inspector.	57
4.7	Callback Element in M file.	58
4.8	Main window of the GLCM extraction programme.	59
4.9	Select Image File window appear.	59
4.10	Select Image File window.	60
4.11	Image file selected display at the Actual Image Axes.	60
4.12	Select And Crop ROI window appear when ROI push button been clicked.	61
4.13	Select and Crop ROI window can have the function of zoom in and out to ease the user selecting region of interest.	61
4.14	After selecting region of interest, ROI axes will display the selected region.	62
4.15	Saving calculated GLCM features will appear when GLCM feature push button been clicked (exporting Structure Matrix into MAT file)	62
4.16	Variable Editor push button call importing matrix data from files or clipboard.	63
4.17	Import Data window appear after selecting import data from file.	63
4.18	Select MAT files to import data.	64
4.19	Import Structure Data from file.	64
4.20	After clicking Finish button 'Variable Editor' will pop-up fill with data of the GLCM features Calculated.	65
4.21	'Variable Editor' shows data of GLCM features autocorrelation.	65
4.22	Data Model.	87
4.23	Key Influencers Report.	88
4.24	Dependency Network	89
4.25	Decision Tree Average Roughness.	90

4.26 Accuracy Chart. 90
4.27 Key Influence Report. 91
4.28 Dependency Network. 92
4.29 Decision Tree. 93
4.30 Accuracy Chart. 94

LIST OF ABBREAVIATIONS

AFC	-	aluminium finishing cut
ANFIS	-	adaptive neuro-fuzzy inference system
ANN	-	Artificial Neural Network
ARC	-	aluminium rough cut
ASA	-	American Standard Association
ASC	-	angular speckle correlation
BMP	-	bitmap
CCD	-	charge coupled device
CMM	-	Coordinate Measuring Machine
CNC	-	Computer numerical control
EBPTA	-	error back propagation training algorithm
FLC	-	Fuzzy logic controller
FN-SRP	-	fuzzy net based surface roughness prediction system
GA	-	Genetic Algorithm
GIF	-	graphics interchange format
GLCM	-	Grey Level Co-occurrence Matrix
GUI	-	Graphical User Interface
ITC	-	Intensity Topography Compatible
JPEG	-	Joint Photographic Experts Group
LR	-	Linear Regression
LSM	-	light scattering method
MSFC	-	mild steel finish cut
MSRC	-	mild steel rough cut
NVA	-	non-value added activity
PS	-	PostScript
PSD	-	Photoshop Document
Ra	-	arithmetic average roughness height
ROI	-	Region of Interest
Rq	-	root mean square roughness
rms	-	root-means-squares

SCM	-	speckle contrast method
SPBI	-	statistical properties of binary images
SQL	-	Structured Query Language
STD	-	standard deviation
TIFF	-	Tagged Image File Format
TSK	-	Takagi-Sugeno-Kang

CHAPTER 1

INTRODUCTION

1.1 Introduction

In a manufacturing plant, activities that are not value added into the products will be classed as a waste. Therefore in every factory, all non-value added activities (NVAs) have to be eliminated. NVAs are identifies through thorough study on each manufacturing activities such as the quality inspection of surface finish. In machining operation; surface roughness measurement consumes additional time and man power resulting in a costly quality inspection. Conventional method of measuring surface roughness has the advantage in terms of simplicity of operation and portability but it has limited flexibility. Conventional method of measuring like the surface indicator is using contact method for measurement. Unlike surface indicator, image processing technique which will be used for this research is not just noncontact measurement but capable of detecting any surface flaw on work piece. There are a few characteristic that be considered when comparing the current available tools for surface roughness measurement such as the easiness if usage, the portability, the measurement capability (sensitivity and measurement span), flexibility of usage area and the usability for other purposes. Table 1.1 compared the currently used surface indicator, laser and image processing technique on their characteristics. If surface roughness measurements are performed using image processing technique, significant time can be saved during production and less man power will be required for inspections of parts features. A full integration of this vision-based inspection system will reduce production time and increase efficiency of inspection activity and quality.

Table 1.1: Comparison of the conventional surface roughness measuring method and the propose image processing technique is stated below (Unal et. al., 2004).

Characteristics	**Image Processing Technique**	**Stylus Profilometry (Surface Indicator)**	**Laser**
Easiness to use	Require software, it will be easier if software is developed with all the function required for surface analysis.	Simple and easy to used, but several reading should be taken for accuracy.	Not as simple as surface indicator.
Sensitivity of Measurement	Good for surface analysis, as it can provide more information of the surface.	Poor for surface analysis, limited information of surface provided.	Very good for surface roughness study
Scanning Dimension	2-D / 3-D	2-D	2-D / 3-D
Flexibility of usage area	Good for laboratory used and also in the field (on production floor, machine shop, etc.	Good for laboratory but not in the field as it required constant environmental factor to maintain accuracy (temperature).	Good for laboratory research but not in application.
Measurement span	Can measure any portion of a surface on work piece depends on the software functions available.	Short to long depend on the purpose of study and the specification of the stylus.	Good, can measured any surface length.

Usability for other purposes	Capable to be used for other purpose besides determine roughness depend on the software functions.	Besides surface roughness, there are no other functions available.	It can be used for other purposes, such as determining the work piece turning speed in turning process.
Cost	Fairly high	Fairly low	Very high
Evaluation	Suitable for roughness measurements in the field of surface study. Software functions can increase.	Suitable for 2-D measurements but with limited functions.	Suitable for variety of studies (surface studies, parameters studies, etc.)

1.2 Problem Statement

Conventional surface roughness measurement currently used is determination of the surface average roughness within the range of the measurement span of the equipment used and getting the average of the values measured by the stylus as it drag across the surface of the specimen of the work piece. In most cases this conventional method requires a totally flat surface of the work piece before commencement of measuring and in addition a jig must be prepared for the work piece that is not in flat form.

In industry, the time saved from an efficient quality inspection time can be converted into cycle time for productivity. Reducing rework in some cases will also contribute to increasing the daily productivity.

The following are a list of some potential disadvantages of using conventional method of measuring surface roughness:

i. Work piece have to be removed and get it to the stylus profilometry to measure as it is difficult to get the stylus to measure when the work piece is still intact with the machine.
ii. Determination of surface roughness only in a linear movement, which mean that if the path taken by the stylus do not have any flaw it will detect as a perfect surface if the flaw is detected then it will give an awkward readings of surface roughness. This will affect greatly when surface roughness readings are to be calculated and get the average.
iii. Stylus profilometry is not flexible measuring equipment, even though the design for stylus is small and portable. Some profile of the work piece might be too narrow to be measured by the stylus.

1.3 Objectives

To determine surface roughness of a round bar work piece using non-contact measuring method in a turning process. The method which will be used is image processing technique, using MATLAB image processing toolbox.

i. To investigate capability of image processing technique to identify surface differences on image of the machine work piece in order to determine surface roughness within the range of standard roughness in turning process.
ii. To design a program with Graphical User Interface (GUI) with the function to determine image region of interest grey level co-occurrence matrix (GLCM) features'.
iii. To analyse empirical correlation that relates the acquired image to the surface roughness value measured from surface roughness tester (stylus profilometry).

1.4 Scopes

The research on Establishment of Mathematical Model of Prediction of Surface Roughness via GLCM Features will include:

- Surface analysis of cylindrical material (aluminium and mild steel) upon completion of conventional turning process which is also known as offline.
- Machining parameters are rough cutting and finishing cutting.
- Image capturing in a constant light intensity and camera lens aperture must be fixed.
- Analysis of image by gathering grey level co-occurrence matrix for texture feature extraction
- Development of data model from texture feature and surface roughness.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Image Processing

Image processing is the first step to prepare the image that has been captured for later use as well as for further analysis. Image is captured using a digital camera and filtered to reduce noise. The image can be further enhanced, altered, segmented, filtered and many more. Image processing is a collection of routines and techniques to improve, simplify, enhance or alter an image (Niku, 2001).

Besides that an image is a representative of a real scene, this image is presented such a way in an array or a matrix, of square pixels (picture elements) arranged in columns and rows. Therefore it may be defined as a 2-dimensional function, $f(x, y)$, this x and y are spatial coordinates and the amplitude of f at any pair of the coordinates is known as intensity of monochrome images whereas colour images are formed by combination of individual 2-D images (RGB) consists of 3 individual component images (Gonzalez et. al., 2004).

Images and some other signals are often described in mathematical models. A signal is a function that depends on some variable with physical meaning, where it can in one dimension (dependent on time), two dimension (image dependent on two coordinates in a plane) three dimensions (describing a volumetric object in space) or higher dimension (Sonka et. al., 2008).

In grey scale image (8-bit) each pixel (picture element) has an assigned intensity that ranges from 0 to 255. Figure 2.1 shows grey scale image which normally known as

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